REMARKS

Favorable reconsideration and allowance of the present application are requested.

By way of the amendment instructions above, many of the originally filed claims have been amended in an effort to clarify the same. Claims 18-19 have been cancelled without prejudice, and new claims 22-52 have been submitted for consideration. Thus, claims 1-17 and 20-52 are pending herein for which favorable reconsideration on the merits is solicited.[1] As will become evident from the following discussion, all claims now pending herein are believed to be in condition for allowance.

I. General Comments

The Applicants' invention is concerned with heat transfer elements, more particularly with heat transfer elements of the type used as radiant panels in the construction of heat exchangers for use in electric power generating stations. As taught by page 1 lines 9 to 26 of the Applicants' specification, there may be around 30,00 square metres (i.e. around 229,913 square feet) of such radiant panels in a single heat exchanger and there may be twelve or more heat exchangers in a single electric power generating station. It will accordingly be readily apparent that even a slight reduction in the cost of such radiant panels will have a major impact on the overall cost of construction of an electric power generating station.

In one embodiment the Applicants have invented a novel heat transfer element which is in the form of a thin panel, which is typically from about 0.4 mm to about 1.2

[1] The claim numbering in the present Amendment employs the corrected claim numbering as presented with the Applicants' Preliminary Amendment dated August 7, 2001 in which it was clarified that claims 1-2<u>1</u> were originally presented for examination herein.

mm thick (i.e. about 0.016 inches to about 0.047 inches thick). Such a panel has not only to be self-sustaining, but must also be resistant to harsh physical conditions, including exposure to hot air and steam moving at high speed at temperatures of up to about 150^0C. It also has to be resistant to corrosive chemicals, such as sulphurous and nitrous acids which may be present in the air stream. Another requirement is for it to be resistant to clogging with soot or debris, which might otherwise clog the radiant panels. Moreover it must also stand up to rapid thermal cycling. It must also conduct heat rapidly from one of its faces to the other. These requirements are, as the Examiner will appreciate, extremely demanding. The need for such properties is taught by the aforementioned passage at page 1 lines 9 to 26, as well as by the paragraph from page 2 line 26 to page 3 line 1, of the Applicants' specification.

Prior art heat transfer elements have traditionally consisted of coated metal panels. However, these rely upon the integrity of the coating for successful operation.

There has also been proposed in United States Patent No. 4,461,347 (Santo et al.), as mentioned in the Applicants' specification, a heat exchanger assembly comprising coaxially arranged inner and outer pipes. The inner pipe can be formed of high strength metal and ensheathed by an extruded heat shrinkable plastics tube of non-reactive material, such as polytetrafluoroethylene or polypropylene. Another prior art proposal is for a plate heat exchanger comprising at least three plate elements consisting of graphite and a fluoropolymer, such as polyvinylidene fluoride is disclosed in European Patent Specification No. 0 203 213 A1 (Künzel). It is also proposed in British Patent Specification No. 2 255 148A (Moore et al.) to construct a structurally composite metal and plastics tube in which the metal forms a tubular core having openings throughout its length occupying at least 5% of its total surface area while the plastics material forms imperforate inner and outer layers, each at least 0.1 mm thick, covering the inside and outside of the metal core and integrally joined through the openings.

The Applicants' inventive heat transfer panel is made (as described, for example, in the Applicants' Example 5) by laminating under appropriate temperature and pressure conditions a pad of glass fibres between two films made of a thermoplastic polymer, more particularly films of polyvinylidene fluoride or of a copolymer containing at least 80% vinylidene fluoride and no more than 20% of another fluorinated monomer selected from tetrafluoroethylene, hexafluoropropylene and vinyl fluoride. Although glass fibres are not normally noted for good thermal conductivity properties, by utilizing glass fibres in an amount corresponding to from about 20% to about 60% by volume of the heat transfer element the Applicants have found that the resulting heat transfer element possesses good thermal transfer properties. It is important that the glass fibres should be chemically resistant and, for this reason, boron-free glass fibres are particularly preferred.

Nowhere is it suggested in the prior art cited by the Examiner that glass fibres can be used in this way, in combination with polyvinylidene fluoride (or with a copolymer containing at least 80% of vinylidene fluoride) in order to form a heat transfer element that exhibits all of the desired properties. Since the Applicants' panels are made by lamination, the glass fibres are substantially all confined to the inner thickness of the panel, while the surfaces of the panel consist substantially of polyvinylidene fluoride (or of a copolymer containing at least 80% of vinylidene fluoride) with essentially no glass fibres being present in the surface layer. Hence the risk of leakage from one surface to another along the glass fibres is substantially obviated. Compared with heat transfer elements constructed from polytetrafluoroethylene, which is not in any event normally regarded as a thermoplastic material and hence is unsuitable for lamination, the Applicants' heat transfer elements have the advantage of requiring relatively little expensive polymer for their formation and, because polyvinylidene fluoride is in any case significantly cheaper than polytetrafluoroethylene, the Applicants' heat transfer elements are significantly cheaper than any comparable product containing

polytetrafluoroethylene. Moreover, since it contains no underlying metal, it is not prone to corrosion, as is the case with conventional coated metal heat transfer elements. A further advantage is that the Applicants' heat transfer elements are lighter in weight than conventional coated metal radiant panels. Since the Applicants' heat transfer elements do not rely for their structural integrity on an underlying metal sheet, there is no risk of failure due to metal corrosion in the event that the protective coating should be damaged.

In another embodiment, the Applicants have invented a novel tubular heat transfer element. This can be made (as described, for example, in the Applicants' Example 6) by making a tape by consolidating glass fibre rovings which have been impregnated with polyvinylidene fluoride (or with a copolymer containing at least 80% of vinylidene fluoride) and then winding the tape onto to mandrel, preferably with 60% of the tape in the length of the pipe and 40% in the inner and outer surfaces of the pipe at an angle of +/- 20^0. Again, the Applicants' tubular heat transfer element relies upon the presence of a high proportion of chemically resistant glass fibres to provide the necessary heat transfer characteristics. It is again emphasized that none of the prior art documents cited by the Examiner teaches such a use for glass fibres.

II. Response to Election/Restrictions

The restriction of the application to claims 1 to 19 is noted with traverse. Specifically, the Applicants disagree with the opinion of the Examiner that evidence of lack of unity is to be found in U.S. Patent No. 5,211,220 (Swozil et al.) and hereby traverse the restriction requirement. In addition, the Applicants reserve the right to file at a later date a divisional application or applications directed to the claims that have been withdrawn from consideration, i.e. claims 20 and 21.

The Examiners reminder regarding possible amendment of inventorship is much appreciated by the Applicants. However, no amendment of inventorship is required in the present application even should the restriction requirement be maintained.

II. Response to Specification Issues

An abstract is provided herewith which is substantively identical to the abstract which was filed in International Patent Application No. PCT/GB00/00363 filed 7 February 2000, upon which the present application is based, and which appears on the front page of the published version of that International patent application, i.e. WO 00/47664.

III. Response to 35 USC §112 Issues

The Examiner rejected claims 1 to 3, 11, 13 to 15, and 17 under 35 USC §112, second paragraph. Applicants suggest that the amendments presented herewith are appropriate to meet such rejection.

IV. Response to 35 USC §103 Issues

Claims 1 to 3, 7, 10 to 13, 14 and 17 attracted a rejection under 35 USC §103(a) as allegedly being unpatentable over Swozil et al. (U.S. Patent No. 5,211,220).

Swozil et al. proposes a tube for a shell and tube heat exchanger comprising a polytetrafluoroethylene tube body wound cross-wise with carbon filament yarn to which a coating of perfluorinated alkoxy polytetrafluoroethylene has been applied. According to the Example, heating to 380□C after wrapping of the tubes is used to form a firm connection between the fibres and the tube. According to column 3 line 2, the fibres can alternatively be glass fibres. Polytetrafluoroethylene is not a thermoplastic material. Moreover it is a perfluorinated polymer so that, apart from the carbon-carbon bonds of the polymer backbone, every pendant substituent is fluorine. The fibres are utilized in

an outer layer on the polytetrafluoroethylene tube in order to increase the bursting strength of the tube but it is not stated that they impart rigidity to the tube. Moreover there is no teaching to use as much as 20% by volume or more up to 60% of the material of the tube of glass fibres. Indeed the Example teaches that only about 60% of the surface of the polytetrafluoroethylene tube is actually covered by the fibres, specifically carbon filament fibres. Such fibres are coated with a fluorine-containing polymer, preferably a polymer of the group consisting of perfluorinated alkoxypolytetrafluoroethylene (PFA), polyvinylethertetrafluoroethylene copolymer (TFA), or tetrafluoroethylenehexafluoropropylene copolymer (FEP) (column 3 lines 12 to 18). Thus, according to the Example of Swozil et al. the resulting tube has an inner surface of polytetrafluoroethylene and an outer surface which comprises in part a perfluorinated polymer, i.e. PFA. Only about 60% of the outer surface of the tube is, it would appear, covered by the carbon fibres and their PFA coating. Moreover no guidance is given by Swozil et al. as to how thick the layer of fibres is to be.

In contrast the Applicants' heat transfer element is made from a ***wholly different*** fluoropolymer which is thermoplastic and which is not perfluorinated, i.e. from polyvinylidene fluoride or from a copolymer of at least 80% by weight of vinylidene fluoride with up to about 20% of at least one other fluorine based monomer. Alternatively it can be made from a mixture of polyvinylidene fluoride or such a vinylidene fluoride copolymer and an acrylic polymer. Moreover the Applicants' heat transfer element is reinforced by fibres made from a chemically resistant glass, preferably a boron-free glass, as taught by page 6 lines 3 to 11 and, in particular, lines 7 and 8. In addition, the glass fibres constitute from 20 to 60% by volume of the volume of the heat transfer element. Swozil et al. provide no suggestion of such a combination of features.

The Examiner has stated:

> "As Swozil et al. teaches the use of glass fibres in tube heat exchangers, glass fibres are necessarily thermally conductive."

This argument is, in the very respectful submission of the Applicants, fallacious. In fact Swozil et al. teach that the fibres are at risk of affecting adversely the heat transfer coefficients of the coated tubes. Thus at column 3 lines 34 to 36, Swozil et al. say:

> "Larger meshes only insignificantly change the heat transfer coefficients of the uncoated tubes ***and are therefore preferred***" (emphasis added).

The implication is that, if small meshes are used, the heat transfer coefficient will be adversely affected. In other words, if too much fibre wrapping is used, the heat transfer coefficient will suffer. Accordingly it is clear, in the submission of the Applicants, that Swozil et al. failed to appreciate that one could form a heat transfer element made entirely from a laminate formed from two thermoplastic films, more particularly films of polyvinylidene fluoride (or of a copolymer containing at least 80% of vinylidene fluoride), with a pad of glass fibres, preferably chemically resistant glass fibres such as boron-free glass fibres, which constitute as much as 60% by volume of the heat transfer element, and still get good heat transfer properties.

The use of glass fibres for reinforcement purposes in plastics structures is of course well known. Swozil et al. propose the use of glass fibres of unspecified type, in an outer layer only, to provide resistance to bursting pressure. It is clear to the person skilled in the art that the purpose of including glass fibres in the structure of Swozil et al. is to prevent bursting of the tube and not to provide good heat transfer characteristics therefor.

As pointed out above, the Applicants' structure has similar materials on both faces, whereas the tube of Swozil et al. is, to quote the Examiner's words, a "dual layer tube heat exchanger" (see page 6 line of the Office Action).

At column 1 lines 14 to 31 of Swozil et al. it is said:

> "It is also known to manufacture shell and tube heat exchangers [sic!] tubes or hollow filaments of fluorine-containing polymers, for example of polytetrafluoroethylene, polytrifluorochloroethylene, polyvinylidene fluoride, copolymers of vinylidene fluoride and hexafluoropropylene and of tetrafluoroethylene and hexafluoropropylene, as disclosed in British Patent No. 1 107 843. The disadvantages of fluorine-containing thermoplasts [sic!] are their low compressive strength in the range of relatively high use temperatures and the comparatively limited fatigue resistance thereof, primarily limited by creep and fatigue. In part the deficiency can be eliminated by addition of fibrous or pulverous reinforcing materials, especially burdening producibility and workability which are essentially made difficult by these additions. This applies in particular for thin-walled tubes intended for heat exchangers."

This passage accordingly envisages mixing a fibrous material with the fluorine-containing polymer which is then presumably moulded or extruded to form a heat exchanger tube. This is a totally different concept from that utilized by the Applicants who teach, according to one embodiment of their invention, lamination of glass fibres between opposed layers of polyvinylidene fluoride or of a copolymer which contains at least 80% by weight of vinylidene fluoride and up to 20% by weight of another fluorine-

containing monomer. The result of such a lamination technique is that the exposed surfaces of the Applicants' heat transfer element in this embodiment consist essentially solely of polyvinylidene fluoride (or of the specified copolymer) with essentially no glass fibres in the surface layers.

According to page 2 lines 35 to 47 of British Patent 1,107,843, which is mentioned by Swozil et al. at column 1 line 21 (and a copy of which is provided herewith for the ready reference of the Examiner):

> "The hollow filaments for the method of the invention may be made from any fluorinated polymer which can be produced in hollow form, ... The walls of these hollow filaments are nonporous and because of their very minute diameter and cylindrical configuration these filaments allow for highly usable strength for design in spite of the fact that the allowable stresses in plastics are less than for metal on a volume basis."

At page 2 lines 54 to 76 of British Patent 1,107.843 there is discussion of illustrative examples of polyfluorinated polymers, including polyvinylidene fluoride and copolymers of vinylidene fluoride and hexafluoropropylene. However, the particularly preferred polymers are copolymers of tetrafluoroethylene and hexafluoropropylene. The size of the hollow filaments is discussed at page 2 lines 77 to 90 of British Patent 1,107,843. The three Examples at page 3 line 59 to page 4 line 10 make it clear that there is no added reinforcement in the hollow filaments.

In his rejection of claims 1 to 3, 7, 10 to 13, 14, and 17 the Examiner noted that Swozil et al. fail to teach that the glass fibres comprise from about 20% to about 60% by volume of the heat transfer element. He went on to say:

> "It would have been obvious to one of ordinary skill in the art at the time that the invention was made to have determined the optimum amount of glass fibre in terms of percentage volume of the heat transfer element to use in the heat exchange element of Swozil et al. that would yield the desired rigidity of the element depending on the desired end user result ...".

As pointed out above, the reason for incorporation of such a high percentage volume of glass fibres in the Applicants' heat transfer element is not simply to impart rigidity but rather to ensure that the heat transfer element has the desired good heat transfer properties. Swozil et al. totally fail to appreciate that use of such a high volume percentage of glass fibres would yield the desired heat transfer properties. Indeed, as pointed out above, Swozil et al. implicitly teach that use of too high an amount of fibres is disadvantageous because they can change significantly the heat transfer coefficients of the uncoated tubes (see column 3 lines 34 to 36 of Swozil et al.). In addition, Swozil et al. teach the use of fibrous reinforcements for wrapping a limited part only of the outside of a tube of a different polymer from that with which the fibres are impregnated. This is wholly different from using fibres embedded in the body of the heat exchange element.

In his criticism of claim 13, the Examiner comments:

> "In regard to claim 13, Swozil et al. teach that larger mesh widths promote bonding between the fibres and the tube body layer (col. 3, lines 29-39); therefore, Swozil et al. teach that the fibres are loosely commingled."

If one has a mesh, then the fibres cannot be loosely commingled. If the Examiner's position is correct, then one would expect to be able to catch fish with a loosely commingled collection of bits of string (and would not need a net), which is clearly impossible. Moreover, as pointed out above, Swozil et al. prefer to limit the amount of fibres used so as not to affect adversely the heat transfer coefficients of the uncoated tubes (see column 3, lines 34 to 36 of Swozil et al.). As further stated above, the Applicants use as much as 20% to 60% by volume of the heat transfer element of glass fibres, not solely for the purpose of imparting rigidity to the element, but so as to ensure that the heat transfer element has good heat transfer characteristics. This is wholly opposite to the teaching of Swozil et al.

In summary the Applicants deny that the subject matter of the amended claims is unpatentable over Swozil et al. under 35 USC §103(a). Hence insofar as the Examiner may deem his rejection of claims 1 to 3, 7, 10 to 13, 14 and 17 to apply to the newly amended claims, such rejection is hereby traversed and reconsideration thereof is respectfully requested.

In a further rejection of claims 4 and 5, the Examiner maintained that these claims are unpatentable under 35 USC §103(a) as being unpatentable over Swozil et al. in view of O'Connor. These claims have been deleted without prejudice. Hence this rejection needs no further comment.

Claim 6 was also rejected by the Examiner under 35 USC §103(a) as being unpatentable over Swozil et al. in view of Kolouch (U.S. Patent No. 5,000,875). This claim has also been cancelled without prejudice so no further comment is required.

Next the Examiner rejected claims 8 and 9 under 35 USC 103(a) as being unpatentable over Swozil et al. in view of Brüning et al. (U.S. Patent No. 5,425,981).

The Applicants have decided to cancel claims 8 and 9 without prejudice so no comment is further required.

Claims 15 and 16 were rejected under 35 USC §103(a) as being unpatentable over Swozil et al. in view of Saito et al. (U.S. Patent No. 4,911,227).

The deficiencies of Swozil et al. have been discussed in detail above. Saito et al. describe at column 6 line 29 et seq. a method of making a heat exchange element in which a sheet of glass fibres made by a customary paper-making method is impregnated with a silica powder dispersion containing polyvinyl alcohol. This is formed into a honeycomb structure which is then dipped in a treating liquid A containing silica powder, C glass flake, mica powder and colloidal silica, calcined at 400^0C, dipped a second time in treating liquid A, dried, dipped in a treating liquid B consisting of ethyl silicate solution, subjected to a steam treatment, and dried. The polyvinyl alcohol would be pyrolysed in the course of the calcining step at 400^0C. Although Saito et al. mentions that "a water soluble acrylic resin" (see column 4 line 37) can be used in place of polyvinyl alcohol, this would also be pyrolysed in the calcining step at 400^0C. Accordingly it is denied that the subject matter of claims 18 and 19 is unpatentable over Swozil et al. in view of Saito et al. Insofar as the Examiner considers that his rejection of claims 18 and 19 is applicable also to the newly amended claims, such rejection is hereby traversed and reconsideration thereof is respectfully requested.

The Examiner further rejected claims 18 and 19 under 35 USC 103(a) as being unpatentable over Swozil et al. in view of Yousuf et al. (U.S. Patent No. 5,229,460).

The disclosure of Swozil et al. and its failure to teach or suggest the subject matter of the Applicants' invention have been discussed extensively above. Yousuf et al. (whose inventors include inventor Welton of the present application) teach use of a fluoropolymer based powder for use as a powder coating composition (see column 1

lines 5 to 10). Such powder coating compositions are typically used for spraying metal objects. Thus Example 1 of Yousuf et al. describes use of the powder compositions made according to that Example for spraying on to an untreated aluminum panel. To make such a powder coating composition Yousuf et al. teach that a fluorohydrocarbon polymer, such as polyvinylidene fluoride, is mixed with an acrylic polymer (see column 2 lines 40 to 46), and other ingredients, such as corrosion inhibiting pigments, dry flow promoting agents, antioxidants, adhesion promoters, and ultraviolet absorbing materials (see column 3 lines 15 to 24). The ingredients are melted, extruded under conditions giving a degree of crystallinity of at least 85%, and the resulting solid mass is then ground to give the final powder composition (see column 6 lines 25 to 40). The resulting powder can be applied to a substrate (such as an untreated aluminum panel) by any suitable means, including electrostatic spray apparatus, a cloud chamber, a fluidized bed, or triboelectric coating apparatus (see column 6 lines 51 to 55). This disclosure of Yousuf et al. is thus from a totally different art from the Applicants' invention and has nothing at all to do with manufacture of heat transfer elements. Moreover, even if it is permissible to combine the teachings of Swozil et al. and Yousuf et al. (which is not admitted), the end result would not be the Applicants' invention of a heat transfer element which contains as much as 20 to 60% by volume of the heat transfer element of chemically resistant glass fibres so as to provide the necessary heat transfer characteristics. In this connection it is especially to be noted that Swozil et el. teach that the whole outer surface of polytetrafluoroethylene tube should not be covered with glass fibres since that would have an adverse effect upon the heat transfer characteristics (see column 3 lines 34 to 36 of Swozil et al. where it is recommended that larger meshes should be used since these "only insignificantly change the heat transfer coefficients of the tubes").

For all these reasons it is denied that the subject matter of claims 18 and 19 is unpatentable over Swozil et al. in view of Yousuf et al. Moreover, if the Examiner

considers that this rejection also applies to the newly amended claims, then such rejection is hereby traversed and reconsideration thereof is respectfully requested.

V. Information Disclosure Statement

The Applicants also wish to draw the attention of the Examiner to European Published Patent Specification No. 0 515 030 A1 (Saito), a copy of which is enclosed. This document first came to the attention of the Applicants when it was cited in a Communication mailed on 13 March 2003 by the Examining Division of the European Patent Office.[2]

The EP '030 document discloses a resin powder composition comprising granules which comprise polytetrafluoroethylene/perfluoro-(alkyl vinyl ether) copolymer particles, 0.05 to 5% by weight of polyethylene sulphide particles having an average particle size of 0.3 to 50 µm, and a heat resistant filler, wherein said granules have an average particle size of 70 to 1000 µm, and a heat resistant filler, and said composition has a porosity of not more than 0.74, a specific shrinkage of not more than 5.1%, and a melt flow rate that satisfies the following equation:

$$\log f \geq -0.70 \log \eta + 2.83$$

where f is the melt flow rate of the resin powder composition, and η is the specific melt viscosity at 372^{0}C of the tetrafluoroethylene/perfluoro(alkyl vinyl ether) copolymer.

Such a composition can be used for lining a substrate, such as a non-stick pan. The thermally resistant filler can be glass fibres. This has no relevance whatsoever to

[2] The undersigned registered attorney therefore hereby certifies that the information contained herein was cited in a communication from a foreign Patent Office in a counterpart foreign application not more than three months prior to the filing of this statement. As such, no fee is believed to be required in order for the Office to consider the cited EP '030 publication on its merits.

the production of heat transfer elements. Nonetheless, consideration of such publication is requested.

VI. Conclusions

In summary, the Applicants submit that the present invention, as defined by the newly amended and presented claims, is both novel and unobvious over the applied references of record. As such, the present application meets all statutory requirements for patentability. Favorable reconsideration of the application is accordingly hereby respectfully requested.

Respectfully submitted,

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